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Shock Value: Electrical Phenomenon in Charge of Ore Formation

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Electrical phenomena may play a more significant role in geology than previously recognised. Recent research [1] showed that gold nuggets can form in quartz veins during earthquakes due to quartz's piezoelectric properties—where mechanical strain generates an electric charge that drives geochemical reactions (piezocatalysis), leading to gold deposition. These findings introduced a novel mechanism for metal accumulation with broad implications beyond gold nugget formation. Given the ubiquity of quartz veining and seismic activity in ore-forming systems, electrochemical metal deposition is also likely influenced by local piezoelectric potentials.

Since naturally occurring voltages are instantaneous and imperceptible, identifying their effects on geological observations remains challenging. This talk will examine the electrical properties of minerals, electrochemical ore-forming processes, and their relationship with piezoelectricity. We will discuss metal concentration mechanisms, such as galvanic redox reactions at conductive micro-junctions [2], and factors governing metal nanoparticle stability and deposition, including zeta potential, electrostatic attraction, and surface potential [3]. Our new experimental results demonstrate how quartz piezoelectricity enhances these mechanisms, increasing metal deposition onto a range of conductive mineral surfaces, particularly sulphides (Fig. 1).

We propose that quartz piezoelectricity promotes electrochemical deposition (i.e., 'electroplating') over spontaneous galvanic reactions and drives nanoparticle movement via electrophoresis rather than electrostatic attraction. We hypothesize that the directionality of applied voltages may govern the galvanic corrosion or protection of sulphides, influencing ore preservation or remobilisation during deposit formation.

Quartz constitutes approximately 12% of Earth's crust and its widespread occurrence suggests that piezoelectricity could significantly impact multiple fields of research across the crustal environment. Despite its potential, there is a lack of published research on electrical processes in geosciences—piezoelectric or otherwise—and further study could help address unresolved questions across multiple disciplines.

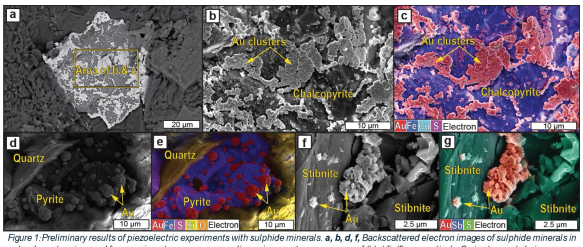

*Figure 1: Preliminary results of piezoelectric experiments with sulphide minerals. **a**, **b**, **d**, **f**, Backscattered electron images of sulphide minerals in natural quartz veins used for experiments. **c**, **e**, **g**, energy-dispersive spectroscopy maps of (b), (d), (f), respectively. Owing to quartz being an insulator and sulphides being semiconductors, the electrochemical deposition of gold from solution preferentially occurs onto sulphide minerals*

[1] Voisey, Christopher R., et al. "Gold nugget formation from earthquake-induced piezoelectricity in quartz." *Nature Geoscience* 17.9 (2024): 920-925.

[2] Moeller, Peter, and G. Kersten. "Electrochemical accumulation of visible gold on pyrite and arsenopyrite surfaces." *Mineralium Deposita* 29 (1994): 404-413.

[3] Eklöf, J., et al. "Guided selective deposition of nanoparticles by tuning of the surface potentiala." *Europhysics Letters* 119.1 (2017): 18004.